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APPRENTICESHIP TRAINING

**Millwright
Program**

Alberta
LEARNING
Apprenticeship and Industry
Training

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Millwright

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Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly-skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Millwright apprenticeship training is a journeyman who will be able:

- understand the principles of sound and safe trade practice.
- interpret drawings, plans, and be able to layout and develop projects according to specifications.
- use the tools of the trade in a safe and proper manner.
- relate to the work of other tradesmen employed in the industry either on construction or in maintenance.
- perform assigned tasks in accordance with quality and production standards required in industry.

Apprenticeship and Industry Training Committee Structure

While government supports Alberta's apprenticeship and industry training system, it is driven by industry, a term which includes both employers and employees. The Alberta Apprenticeship and Industry Training Board, with the support of Alberta Learning, oversees the system. But the system relies on a network of industry committees. These committees include local and provincial apprenticeship committees (LACs and PACs) in the designated trades and occupational committees in the designated occupations, as well as other committees such as provisional committees established before the designation of a new trade or occupation comes into effect. All these committees are composed of equal numbers of employers and employees. The network of industry committees is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the Board can set up a LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. Local Apprenticeship Committees:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level.
- help settle certain kinds of issues between apprentices and their employers.
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee.
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. Provincial Apprenticeship Committees:

- identify the training needs and content for their trade.
- recommend to the Board the standards for training and certification for their trade.
- monitor the activities of local apprenticeship committees in their trade.
- make recommendations to the Board about the designation of trades and occupations.
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade.
- may participate in resolving any apprenticeship-related disputes between employers and employees.

Millwright PAC Members

Mr. G. Becker	Edmonton.....	Presiding Officer
Mr. K. Garvey	Calgary.....	Employer
Mr. L. Falconer	Edmonton.....	Employer
Mr. G. Grieb.....	Edmonton.....	Employer
Mr. J. Hazeldean	Edmonton.....	Employee
Mr. D. Harrish.....	Edmonton.....	Employee
Mr. C. Osmond.....	Fort McMurray.....	Employee
Mr. S. Cote	Hinton.....	Employee

The Alberta Apprenticeship and Industry Training Board (Board)

The mandate of the Alberta Apprenticeship and Industry Training Board relates to the standards and requirements for training and certification in programs under the *Apprenticeship and Industry Training Act*. The Board provides advice to the Minister of Learning on the training and certification of people in designated trades and occupations and on the needs of the Alberta labour market for skilled and trained persons. The Board also makes orders and regulations respecting standards and requirements for apprenticeship programs and the training of apprentices and for training and certification in designated trades and occupations, and the criteria or requirements for granting and recognizing trade and other certificates.

The 13-member Board consists of a chairman, eight members representing trades and four members representing other industries. The trades and other industry members are equally represented by employer and employee representatives.

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees and the public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and environments can be created by controlling the variables and behaviours that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy, safe attitude towards prevention of accidents.

A tradesperson is possibly exposed to more hazards than any other person in the work force and, therefore, should be familiar with and apply the Occupational Health and Safety Act and Regulations dealing with personal safety and the special safety rules applying to each task.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities

The employer is responsible for:

- providing and maintaining safety equipment and protective devices.
- enforcing safe working procedures.
- providing safeguards for machinery, equipment and tools.
- observing all accident prevention regulations.
- training employees in the safe use and operation of equipment.

Employee's Responsibilities

The employee is responsible for:

- working in accordance with the safety regulations pertaining to the job environment.
- working in such a way as not to endanger themselves or fellow employees.

Workplace Health and Safety's Responsibilities:

Workplace Health and Safety (Alberta Human Resources and Employment) will conduct periodic inspections of the workplace to ensure that safety regulations for industry are being observed.

Technical Training Establishment

Alberta Learning, Apprenticeship and Industry Training offer your apprenticeship training program. Staff and facilities for delivering the program are supplied by:

- Northern Alberta Institute of Technology
- Southern Alberta Institute of Technology
- Keyano College
- Fairview College

**Procedures For Recommending
Revisions To The Course Outline**

Apprenticeship and Industry Training, Industry Programs and Standards has prepared this course outline in partnership with the Millwright Provincial Apprenticeship Committee.

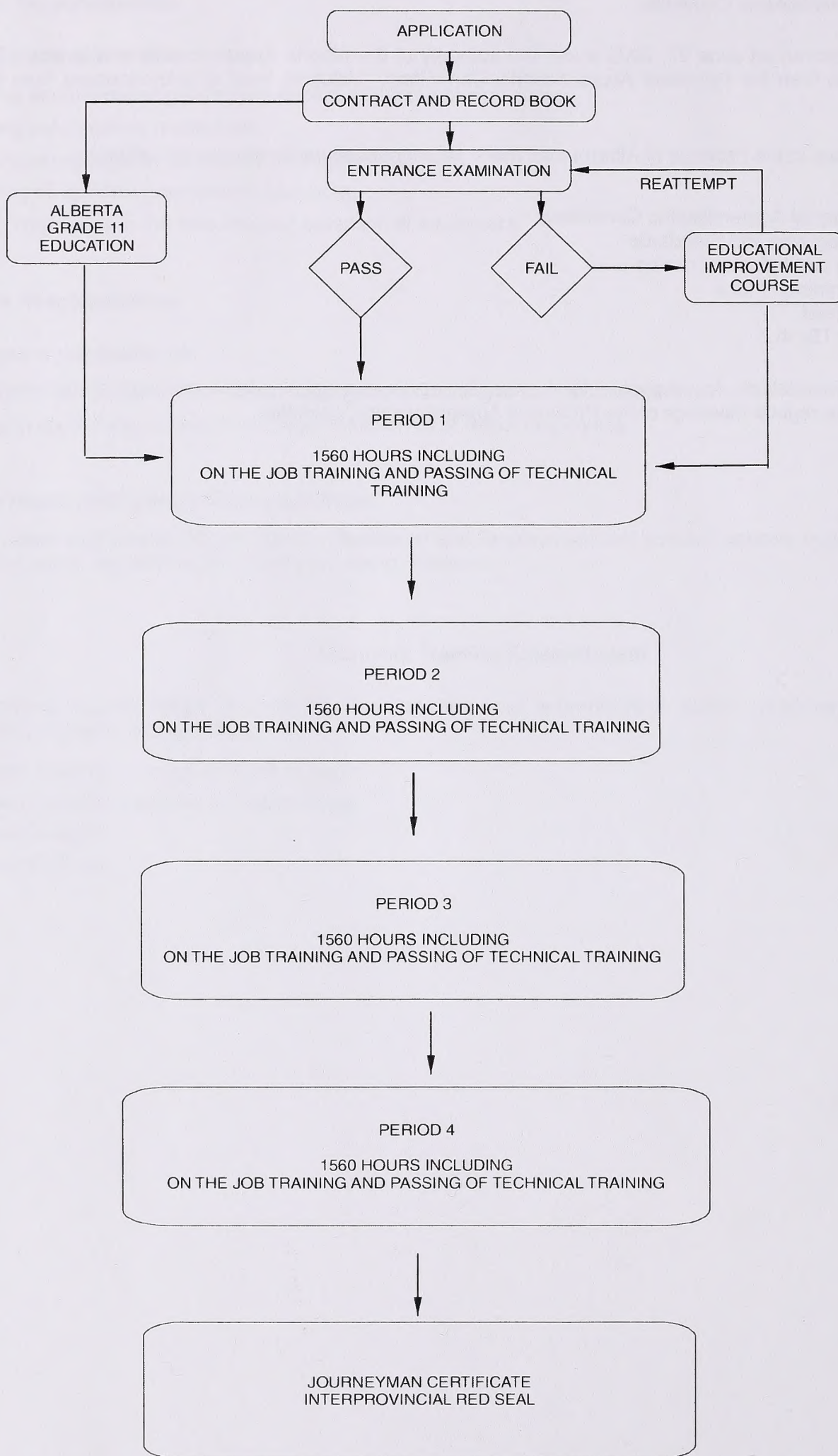
This course outline was approved on June 27, 2003 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry and the institutions.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Millwright Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

Apprenticeship Route Toward Certification



Millwright Training Profile

FIRST PERIOD

(240 Hours)

SECTION ONE

SAFETY

160101

8 Hours



A

General Safety

160101a

3 Hours

B

Fire Safety

160101b

2 Hours

C

WHMIS

160101c

1 Hour

D

Ladders and Scaffolds

160101d

2 Hours

SECTION TWO

MEASUREMENT AND LAYOUT

160102

15 Hours



A

Measurement Basics

160102a

5 Hours

B

Measuring Tools

160102b

2 Hours

C

Layout

160102c

2 Hours

D

Precision Measuring Tools

160102d

6 Hours

SECTION THREE

BENCHWORK

160103

8 Hours



A

Benchwork (Non-cutting Hand Tools)

160103a

3 Hours

B

Benchwork (Hand Held Cutting Tools)

160103b

5 Hours

SECTION FOUR

THREADS AND FASTENERS

160104

9 Hours



A

Threaded Fasteners and Locking Devices

160104a

3 Hours

B

Non-Threaded Fasteners and Locking Devices

160104b

3 Hours

C

Installation and Removal of Fasteners

160104c

3 Hours

SECTION FIVE

GRINDERS AND SAWS

160105

5 Hours



A

Grinders

160105a

2 Hours

B

Power Saws

160105b

3 Hours

SECTION SIX

MACHINING

160106

24 Hours



A

Drilling

160106a

6 Hours

B

Milling

160106b

3 Hours

C

Lathe Construction and Accessories

160106c

6 Hours

D

Lathe Operations

160106d

7 Hours

E

Tapers

160106e

1 Hour

F

Machine Cutting Fluids

160106f

1 Hour

SECTION SEVEN

METALLURGY

160107

5 Hours



A

Metallurgy

160107a

5 Hours

SECTION EIGHT

MACHINE ALIGNMENT

160108

11 Hours



A

Grouting, Levelling, and Anchoring

160108a

3 Hours

B

Rim and Face Shaft Alignment

160108b

8 Hours

SECTION NINE

A

B

RIGGING
160109 14 Hours



Rigging Procedures
160109a 10 Hours

Crane and Hoists
160109b 4 Hours

SECTION TEN

TRADE MATH
32 Hours



Manipulation of Numbers,
Fractions and Decimals

Order of Operations

Tables

Measurement and
Conversions

Ratio and Proportion

Calculating Percent

Circles

Triangle Terminology and
Special Triangles

Surface Speed

SECTION ELEVEN

APPLIED PRINT READING
24 Hours



Introduction to Print Reading

Isometric and Orthographic
Views

Sectional Views

Commercial Shape

Fasteners

Applied Print Reading

SECTION TWELVE

SHOP WORK
85 Hours



Measurement and Layout

Benchwork

Threads and Fasteners

Grinders and Saws

Machining

Metallurgy

Machine Alignment

Rigging

SECOND PERIOD

(240 Hours)

SECTION ONE

GASKETS
160201 6 Hours



Gaskets
160201a 6 Hours

SECTION TWO

BEARINGS AND SEALS
160202 22 Hours



Anti-Friction Bearing
Classification and
Identification
160202a 3 Hours

Anti-Friction Bearing
Removal and Installation
160202b 8 Hours

Plain Bearings
160202c 5 Hours

Bearing Maintenance
160202d 4 Hours

Bearing Seals and Pillow
Blocks
160202e 2 Hours

SECTION THREE**POWER TRANSMISSION**

160203

44 Hours

**A****Couplings**

160203a

8 Hours

B**Clutches and Brakes**

160203b

8 Hours

C**Shafting, Fits and Accessories**

160203c

4 Hours

D**Power Transmission—Belts**

160203d

6 Hours

E**Power Transmission—Chain**

160203e

6 Hours

F**Gearing Fundamentals**

160203f

5 Hours

G**Gear Installation and Maintenance**

160203g

5 Hours

H**Variable Speed Power Transmission Devices**

160203h

2 Hours

SECTION FOUR**ALIGNMENT**

160204

8 Hours

**A****Cross Dial Alignment**

160204a

8 Hours

SECTION FIVE**RECIPROCATING COMPRESSORS**

160205

24 Hours

**A****Compressor Fundamentals**

160205a

4 Hours

B**Repair of Compressor Stationary Components**

160205b

4 Hours

C**Repair of Compressor Moving Components**

160205c

4 Hours

D**Repair of Compressor Valves and Gas Sealing**

160205d

4 Hours

E**Compressor Servicing**

160205e

4 Hours

F**Compressor Overhaul and Start-up Procedures**

160205f

4 Hours

SECTION SIX**CUTTING AND WELDING**

160206

8 Hours

**A****Oxyacetylene Equipment and Procedures**

160206a

5 Hours

B**Electrical Arc Welding**

160206b

3 Hours

SECTION SEVEN**LUBRICATION**

160207

8 Hours

**A****Lubrication**

160207a

8 Hours

SECTION EIGHT**TRADE MATH**

24 Hours

**A****Review of First Period Material****B****Solving Related Trade Calculations****C****Mechanics of Simple Machines****D****Atmospheric Pressure and Gas Laws****E****Coefficient of Expansion****F****Alignment****SECTION NINE****APPLIED PRINT READING**

24 Hours

**A****Review of First Period Print Reading****B****Welding Specifications****C****Practical Application of Print Theory****SECTION TEN****SHOP WORK**

72 Hours

**A****Gaskets****B****Bearings and Seals****C****Power Transmission****D****Alignment****E****Reciprocating Compressors****F****Cutting and Welding**

G

Lubrication

**THIRD PERIOD
(240 Hours)****SECTION ONE****HYDRAULIC AND PNEUMATICS**

160301 44 Hours

A

Introduction to Hydraulics

160301a 9 Hours

B

Hydraulic Valves

160301b 5 Hours

C

Hydraulic Pumps and Actuators

160301c 6 Hours

D

Accessories, Fluids and Seals

160301d 6 Hours

E

Troubleshooting and Maintenance

160301e 6 Hours

F

Pipe

160301f 4 Hours

G

Valves

160301g 2 Hours

H

Pneumatic Systems

160301h 6 Hours

SECTION TWO**INDUSTRIAL REFRIGERATION
AND HEAT EXCHANGERS**

160302 14 Hours

A

Industrial Refrigeration

160302a 6 Hours

B

Heat Exchangers

160302b 6 Hours

C

Insulation

160302c 2 Hours

SECTION THREE**EXPLOSIVE AND AIR TOOLS**

160303 5 Hours

A

Air Tools

160303a 2 Hours

B

Explosive Actuated Tools

160303b 3 Hours

SECTION FOUR**COMPRESSORS AND FANS**

160304 26 Hours

A

Screw Compressors and Lobe Blowers

160304a 8 Hours

B

Vane and Liquid Compressors

160304b 8 Hours

C

Dynamic Compressors

160304c 7 Hours

D

Fans

160304d 3 Hours

SECTION FIVE**DRYERS**

160305 8 Hours

A

Gas and Air Dryers

160305a 8 Hours

SECTION SIX**ALIGNMENT AND SURVEY**

160306 14 Hours

A

Laser Shaft Alignment

160306a 4 Hours

B

Optical Levelling and Alignment

160306b 6 Hours

C

Machine Levelling

160306c 4 Hours

SECTION SEVEN**COMPUTER IN INDUSTRY**

160307 17 Hours

A

Information Gathering, Computers and Catalogues

160307a 8 Hours

B

Managed Maintenance Systems

160307b 9 Hours

SECTION EIGHT**NON-DESTRUCTIVE TESTING**

160308 4 Hours

A

Non-Destructive Testing

160308a 4 Hours

SECTION NINE**ELECTRICAL**

160309

12 Hours

**A**

Electrical Principles

160309a

6 Hours

B

Practical Electricity

160309b

6 Hours

SECTION TEN**TRADE MATH**

16 Hours

**A**Hydraulic, Electrical and
Advanced Mechanical
Calculations**SECTION ELEVEN****PRINT READING**

16 Hours

**A**Reading, Interpretation and
Cross Reference of
Drawings of the Various
Systems**B**Reading Isometric or
Orthographic Multi-view
Sketches of Complete
Systems**SECTION TWELVE****SHOP WORK**

64 Hours

**A**

Hydraulics and Pneumatics

BIndustrial Refrigeration and
Heat Exchangers**C**

Explosive and Air Tools

D

Compressors and Fans

E

Dryers

F

Alignment and Survey

G

Computer in Industry

H

Non-Destructive Testing

I

Electrical

**FOURTH PERIOD
(240 Hours)****SECTION ONE****PRIME MOVERS**

160401

49 Hours

**A**Stationary Independent
Engine Fundamentals

160401a

3 Hours

BEngine Component
Identification and Repair

160401b

10 Hours

CEngine Systems and
Servicing

160401c

9 Hours

DEngine Installation
and Start-up

160401d

2 Hours

E

Steam Turbines

160401e

12 Hours

F

Gas Turbines

160401f

6 Hours

G

Governors

160401g

7 Hours

SECTION TWO**VIBRATION**

160402

20 Hours

**A**

Vibration Analysis

160402a

8 Hours

B

Balancing

160402b

4 Hours

CElectronic Controls and
Troubleshooting

160402c

4 Hours

DIndustrial Controls:
Schematics, Ladder
Diagrams and Logic Control

160402d

4 Hours

SECTION THREE**MACHINE LEVELLING**

160403

7 Hours

**A**

Advanced Alignment

160403a

7 Hours

SECTION FOUR

PUMPS 160404 16 Hours	⇒	A	B	C
		Dynamic Pump Selection 160404a 4 Hours	Dynamic Pump Construction 160404b 6 Hours	Positive Displacement Pumps 160404c 4 Hours
		D		
		Pump Operation and Repair 160404d 2 Hours		

SECTION FIVE

MECHANICAL SEALS AND PACKING 160405 8 Hours	⇒	A	B
		Mechanical Seals 160405a 5 Hours	Compression Packing 160405b 3 Hours

SECTION SIX

CONVEYOR SYSTEMS 160406 16 Hours	⇒	A	B	C
		Belt Conveyors 160406a 6 Hours	Chain, Bucket and Screw Conveyors 160406b 5 Hours	Package Handling Roller Conveyors 160406c 5 Hours

SECTION SEVEN

PLANNING AND SCHEDULING 160408 4 Hours	⇒	A
		Maintenance Planning 160408a 4 Hours

SECTION EIGHT

TRADE MATH 16 Hours	⇒	A	B
		Hydrostatic Head as Applied to Centrifugal Pumps	Advanced Problem Solving

SECTION NINE

PRINT READING 24 Hours	⇒	A
		Reading, Interpretation and Cross Reference of Industrial Drawings

SECTION TEN

WORKING AND COACHING SKILLS AND ADVISORY NETWORK 0 Hours	⇒	A
		Working Coach Skills and Advisory Network

SECTION ELEVEN

SHOP WORK 80 Hours	⇒	A	B	C
		Prime Movers	Vibration	Machine Levelling
		D	E	F
		Pumps	Mechanical Seals and Packing	Conveyor Systems
		G		
		Planning and Scheduling		

NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training

**FIRST PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE**

Due to the nature of the work of the Millwright trade it is imperative that safety, WHMIS and environmental concerns be taught on a continuous basis throughout the entirety of this course.

It is industry's intent that the practical portion of the program enhances the theory section of the course outline.

***UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE
FOLLOWING OUTCOMES AND OBJECTIVES.***

SECTION ONE SAFETY 8 HOURS

A. General Safety 3 Hours

Outcome: Describe safe work practices and environmental protection.

1. Explain responsibilities of the employee, employer, and government.
2. Describe General Safeties and Accident Prevention.
3. Describe Environmental Protections and Material Handling.
4. Describe Personal Protective Equipment and Practices Used In Industrial Applications.
5. Explain Breathing Air Safeguards.
6. Define Industrial Safety Applications.

B. Fire Safety 2 Hours

Outcome: Identify and describe fire classes, extinguishers, prevention, detection, cleanup and restoration.

1. Describe the classes of fires and the appropriate fire extinguishers suitable to fight each of these fires.
2. Describe procedures and equipment related to preventing, detecting and warning of fires.
3. Describe fire cleanup and restoration procedures.

C. WHMIS 1 Hour

Outcome: Apply the requirements of WHMIS to the work site.

1. Describe the three key elements of WHMIS.
2. Identify WHMIS hazard symbols.
3. Interpret the Material Safety Data Sheet (MSDS).

D. Ladders and Scaffolds 2 Hours

Outcome: Identify and describe types and applications of ladders and scaffolding.

1. Describe the use of various types of ladders.
2. Describe the use of various types of scaffolds.

SECTION TWO MEASURING AND LAYOUT 15 HOURS

A. Measurement Basics 5 Hours

Outcome: *Define the limits, tolerances, allowances and fits of various machine parts in both imperial and metric SI (International System of Units) terms.*

1. Convert measurements between fractions and decimals.
2. Define limits, tolerances, allowances and fits in imperial terms.
3. Define limits, tolerances, allowances and fits in metric SI terms.

B. Measuring Tools 2 Hours

Outcome: *Describe the use of measuring tools for the millwright trade.*

1. Assess the effect of temperature change on the dimensions of objects being measured, with regard to various materials.
2. Identify basic measuring tools used in the millwright trade.
3. Describe comparison measurement.
4. Describe the use of squares and protractors.

C. Layout 2 Hours

Outcome: *Describe layout procedures and identify layout tools.*

1. Identify the tools used for layout procedures.
2. Explain layout purpose and procedures.

D. Precision Measuring Tools 6 Hours

Outcome: *Describe the use of precision measuring tools.*

1. Describe vernier instruments and their uses.
2. Describe the types of micrometers and their uses.
3. Describe comparison measurement using dial indicators.

SECTION THREE BENCHWORK 8 HOURS

A. Benchwork (Non-cutting tools) 3 Hours

Outcome: *Identify and describe use of non-cutting hand tools.*

1. Identify common tools used for performing non-cutting bench-work procedures.
2. Describe hydraulic jacks, pullers and presses.
3. Describe methods used in the workshop for cleaning machine parts (non-cutting).

B. Benchwork (Hand Held Cutting Tools) 5 Hours**Outcome:** *Describe the correct use and maintenance of cutting type hand tools.*

1. Describe the use and maintenance of common hand-held cutting tools used in bench-work.
2. Describe the use of abrasive cloths and the process of hand lapping.
3. Describe the care and use of taps and dies.
4. Describe the care and use of hand reamers and broaches.

SECTION FOUR THREADS AND FASTENERS 9 HOURS**A. Threaded Fasteners and Locking Devices 3 Hours****Outcome:** *Identify metric and imperial threaded fasteners and describe typical applications.*

1. List reasons for and describe personal safety equipment required when working with fasteners and anchors.
2. Identify and describe various threaded fasteners and their applications.
3. Identify metric and imperial thread classes and fits.
4. Identify and list the types and purposes of threads and thread forms.
5. Calculate and list reasons for calculating necessary thread dimensions.
6. Describe thread measuring tools, methods and procedures.
7. Describe thread manufacturing methods.

B. Non-Threaded Fasteners and Locking Devices 3 Hours**Outcome:** *Explain non-threaded fasteners and locking devices.*

1. Identify the types and purposes of non-threaded fasteners.
2. Explain the types and applications of locking devices.

C. Installation and Removal of Fasteners 3 Hours**Outcome:** *Explain the installation and removal of fasteners.*

1. Describe methods of removing broken fasteners and tools and thread reconditioning.
2. Explain the theory of tensioning.
3. Describe methods of tensioning.

SECTION FIVE GRINDERS AND SAWS 5 HOURS**A. Grinders 2 Hours****Outcome:** *Describe the safe use and maintenance of grinders.*

1. Explain the safety rules pertaining to offhand grinder use.
2. Explain the operation, types, parts and application of offhand grinders.
3. Describe grinding wheel selection, installation and maintenance procedures.

B. Power Saws 3 Hours**Outcome:** *Describe metal and wood cutting saws used in industry.*

1. Describe power hacksaws, their operation, application and attachments.
2. Describe band saws, their operation, application and attachments.
3. Describe abrasive cut-off saws, their operation, application and attachments.
4. Describe chainsaws, their operation, application and attachments.

SECTION SIX MACHINING.....24 HOURS**A. Drilling 6 Hours****Outcome:** *Describe the procedures for operating drilling machines.*

1. Describe types, parts and applications of drilling machines.
2. Describe holding devices for machines and tools.
3. Describe drilling tools and their applications.
4. Explain the operation, speeds and feeds of drilling machines.
5. Describe care and maintenance of drilling tools.
6. Describe care and maintenance of drilling machines.

B. Milling 3 Hours**Outcome:** *Describe the safe use and maintenance of milling machines.*

1. Describe types, parts and applications of milling machines.
2. Describe milling tools and accessories and their applications.
3. Explain the operation, speeds and feeds of milling machines.

C. Lathe Construction and Accessories 6 Hours**Outcome:** *Describe the sizing, parts, accessories and attachments of lathe types.*

1. Describe lathe safety.
2. Describe the construction of lathes.
3. Describe work holding devices.
4. Describe lathe accessories.
5. Describe tool holding devices.

D. Lathe Operations 7 Hours**Outcome:** *Describe the safe use and maintenance of engine lathes.*

1. Explain cutting and forming tools and sharpening procedures.
2. Describe lathe turning operations.
3. Describe lathe boring operations.

4. Describe lathe threading operations.
5. Describe lathe surface finishing operations.
6. Describe lathe maintenance.

E. Tapers 1 Hour

Outcome: *Apply taper systems to machining operations.*

1. Describe taper applications and installation of tapers.
2. Describe manufacture and repairs of tapers.

F. Machine Cutting Fluids 1 Hour

Outcome: *Apply lubricants to reduce friction and increase efficiency.*

1. Describe functions of cutting fluids.
2. Describe applications for cutting fluids.

SECTION SEVEN METALLURGY 5 HOURS

A. Metallurgy 5 Hours

Outcome: *Select the correct type of metal for an application.*

1. Explain the physical properties of metals.
2. Describe metal manufacturing processes.
3. Describe types and classifications of metals.
4. Explain the heat treatment of metals.
5. Explain tensile and hardness testing of metals.

SECTION EIGHT MACHINE ALIGNMENT 11 HOURS

A. Grouting, Levelling, and Anchoring 3 Hours

Outcome: *Describe machine levelling and grouting procedures.*

1. Describe levelling tools, equipment and procedures
2. Explain the types, purposes and methods of grouting.

B. Rim and Face Shaft Alignment..... 8 Hours

Outcome: *Align two machine shafts using the rim and face method.*

1. List the reasons for aligning machine shafts.
2. Describe pre-alignment procedures
3. Describe machine shaft alignment procedures with regards to the rim and face method of shaft alignment.

4. Determine the alignment corrections required to align two machine shafts in the vertical plane, using the rim and face formula method.
5. Determine the alignment corrections required to align two machine shafts in the horizontal plane, using the rim and face formula method.

SECTION NINE RIGGING 14 HOURS

A. Rigging Procedures 10 Hours

Outcome: *Describe rigging and hoisting equipment and procedures.*

1. Describe the construction of wire rope.
2. Describe the construction and use of steel and fibre slings.
3. Describe hoisting equipment hardware.
4. Describe construction and use of chain and chain slings.
5. Describe the construction of fibre rope and the purpose and use of knots.
6. Estimate the weight of various objects when given the size, shape and material.
7. Describe hand-rigging equipment.
8. Describe standard hand signals used for rigging and hoisting operations.
9. Describe hoisting and load moving procedures.

B. Cranes and Hoists 4 Hours

Outcome: *Use cranes and hoists for lifting and moving objects.*

1. Describe the types of mobile cranes.
2. Describe the set up and safety procedures for mobile cranes.
3. Describe the electric overhead traveling cranes.
4. Describe electric overhead traveling crane inspection procedures.

SECTION TEN TRADE MATH 32 HOURS

A. Manipulation of Numbers, Fractions and Decimals

1. Explain fractions including:
 - a) common
 - b) proper
 - c) decimal
 - d) improper
 - e) lowest common denominator
 - f) lowest term of fraction
2. Explain and perform basic calculations including:
 - a) adding
 - b) multiplying
 - c) subtracting
 - d) dividing
 - e) signs of operation
 - f) fractions to decimals (vise versa)

- g) mixed numbers
- h) positive/negative number
- i) rounding off

B. Order of Operations

1. Explain the usage of mathematics operations and tables including:
 - a) the symmetry property
 - b) the addition property
 - c) the subtraction property
 - d) the division property
 - e) the multiplication property
 - f) the order of operation property

C. Tables

1. Explain the use of tables including:
 - a) squares
 - b) cubes
 - c) square roots
 - d) cube roots
 - e) area of circle
 - f) chord tables
 - g) chart and graph tables
2. Perform necessary calculations.

D. Measurement and Conversions

1. Explain Imperial and ISO systems including:
 - a) terminology of the units for
 - i) linear
 - ii) area
 - iii) volume
 - iv) fluid capacity
 - v) mass
 - vi) temperature
 - b) flexibility of the units
2. Calculate ISO - Imperial conversions.

E. Ratio and Proportion

1. Explain and demonstrate usage of ratio and proportion calculations including extremes and means.
2. Explain and calculate pulley and gear systems including:
 - a) simple pulleys and gear trains
 - b) compound pulley, spur and worm gear systems
 - i) speeds
 - ii) diameters
 - iii) teeth
 - iv) surface speed per minute

F. Calculating Percent

1. Explain and demonstrate the usage of percentage calculations including:
 - a) decimal fractions
 - b) decimal numbers

- c) fractions
- d) by ratio and proportion
- e) by fractions and multiplication

G. Circles

1. Explain circle geometry including:
 - a) radius
 - b) diameter
 - c) circumference
 - d) area
 - e) π
 - f) chords - circle layout
 - g) arcs

H. Triangle Terminology and Special Triangles

1. List the types of triangles and explain their differences including:
 - a) isosceles
 - b) right
 - c) equilateral
 - d) oblique
2. Explain and perform right angle trigonometry including:
 - a) right angle
 - b) sine
 - c) cosine
 - d) tangent
3. Explain and apply the Pythagorean theorem.
4. Explain and apply special triangles including:
 - a) $30^\circ - 60^\circ - 90^\circ$
 - b) $45^\circ - 45^\circ - 90^\circ$
 - c) 3 - 4 - 5
 - d) 5 - 12 - 13
5. Using special triangles as similar triangles for the following:
 - a) problems involving squares and hexagons
 - b) problems involving hole locations

I. Surface Speed

1. Explain SFM and MPM.

SECTION ELEVEN APPLIED PRINT READING 24 HOURS

A. Introduction to Print Reading

1. Describe the types of lines and explain their applications on mechanical component prints and sketches including:
 - a) visible and centre lines
 - b) dashed or hidden lines
 - c) dimension, extension and leader lines
2. List and describe proper print terminology and dimensioning methods including:
 - a) dimensioning
 - i) arrowheads and dimensions inside extension lines

- ii) leader lines
 - iii) arrowheads outside and dimensions inside extension lines
 - iv) arrowheads and dimensions outside the extension lines
 - v) arrowheads inside and dimensions outside the extension lines
 - b) dimensioning tapers and angles
 - i) amount of taper
 - ii) large or small diameter
 - iii) length of taper
 - c) dimensioning holes, circles, chamfers, arcs, threads, countersinks, drills, bores, spotfacing and radii
 - i) methods and their applications
 - ii) notes on prints and drawings
 - iii) abbreviations on prints and drawings
3. Explain the purpose of dual dimensioning on prints.

B. Isometric and Orthographic Views

1. Identify and describe isometric and orthographic views including:
 - a) 6 views and their relative positions
 - b) the "key" view
 - c) the three common views
 - d) sketching various views
 - e) uses of two view projection
2. Perform sketching and dimensioning of orthographic and isometric views.
3. Perform and explain estimating dimensions.

C Sectional Views

1. Explain and identify purpose of sectional views.
2. Describe full and half sectional views.
3. Identify and explain cutting plane and symmetry.
4. Explain and describe method of indicating cutting plane lines.
5. Identify sectional lines including:
 - a) general purpose and cast iron
 - b) steel, brass, bronze and aluminum
 - c) full and half sectional views
 - d) adjacent parts
 - e) removed and revolved sections
 - f) material symbols
6. Identify parts not requiring section lines including:
 - a) pins
 - b) rivets
 - c) screws
 - d) other
7. Explain and identify conventional break methods including:
 - a) for round and rectangular objects
 - b) purpose of such breaks

D. Commercial Shape

1. Identify and sketch commercial shapes.

2. List the methods of identifying steel and non-ferrous metals including:

- a) round
- b) hex
- c) octagon
- d) square
- e) rectangular
- f) pipe
- g) angle
- h) I-beams
- i) U-channel
- j) H-beam
- k) T-bars
- l) synthetics
- m) hollow structural steel

E. Fasteners

1. Identify thread, fastener, keys, etc., and other fastener symbols on prints including:

- a) semi-conventional representation

2. Perform sketching of thread, terminology, fastener, keys and other fastener symbols as follows:

- a) thread specifications
 - i) O.D. and number of threads
 - ii) thread series
 - iii) external or internal
 - iv) class of fit
 - v) hand of thread
- b) terminology
 - i) blind hole
 - ii) tap drill sizes
- c) fasteners
 - i) head and point sizes
 - ii) fastener specifications
 - iii) finished and semi-finished
 - iv) types of threaded fasteners
 - v) styles of head recesses
 - vi) types of non-threaded fasteners
- d) keys, keyways, and keyseats
 - i) types and their specifications on prints
 - ii) sketching keyways and keyseats
- e) other fasteners
 - i) washers, nuts and pins
 - ii) springs and rivets

F. Applied Print Reading

1. Identify and interpret limits, fits, and tolerances of non-ferrous metals and synthetic materials including:

- a) definitions
- b) applications
- c) symbols
- d) accumulation of tolerances

2. Interpret and identify working drawings from sketches including:

- a) title block
- b) notes and dimensioning
- c) detail and assembly sketches

3. Identify and interpret surface finishes.

SECTION TWELVE.....SHOP WORK.....85 HOURS

- A. Measurement and Layout**
- B. Benchwork**
- C. Threads and Fasteners**
- D. Grinders and Saws**
- E. Machining**
- F. Metallurgy**
- G. Machine Alignment**
- H. Rigging**

**SECOND PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE**

**UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE
FOLLOWING OUTCOMES AND OBJECTIVES.**

SECTION ONE GASKETS 6 HOURS

A. Gaskets 6 Hours

Outcome: *Describe the installation and maintenance of gaskets used in industrial machinery.*

1. Describe the safety rules and precautions applicable to the installation, removal and replacement of gaskets.
2. Describe the types of gasket joints common in industry.
3. List the types and applications of various kinds of gasket material.
4. Describe joint disassembly, and gasket removal techniques.

SECTION TWO BEARINGS AND SEALS 22 HOURS

A. Anti-Friction Bearing Classification and Identification 3 Hours

Outcome: *Select appropriate anti-friction bearings for specified applications.*

1. Identify the type, parts and functions of common anti-friction bearings.
2. Describe the type, size and features of anti-friction bearings from the bearing code.

B. Anti-Friction Bearing Removal and Installation..... 8 Hours

Outcome: *Describe the replacement of anti-friction bearings.*

1. Describe the various procedures used to remove anti-friction bearings.
2. Determine the correct shaft and housing sizes required to provide the correct fit to the anti-friction bearing.
3. Describe the preparations required before mounting anti-friction bearings.
4. Describe the drive or press-on methods of mounting anti-friction bearings.
5. Describe the oil injection and hydraulic nut methods of mounting anti-friction bearings.
6. Describe the various hot mounting procedures used to install anti-friction bearings.
7. Describe the procedures for setting internal clearances in anti-friction bearings.

C. Plain Bearings 5 Hours

Outcome: *Describe the application, installation and remanufacture of plain bearings.*

1. Describe the construction, function and application of plain bearings.
2. Describe the characteristics of the common plain bearing materials.
3. Describe the installation of plain bearings.

4. Describe appropriate safety measures applicable to Babbitt pouring.
5. Describe Babbitt pouring and fitting procedures.

D. Bearing Maintenance 4 Hours

Outcome: *Reduce the frequency of bearing failures.*

1. Describe the symptoms of bearing failure.
2. Describe the causes of bearing failure.
3. Describe bearing inspection methods.
4. Describe bearing lubrication methods.
5. Describe bearing maintenance procedures.

E. Bearing Seals and Pillow Blocks 2 Hours

Outcome: *Describe the characteristics and applications of bearing seals and pillow blocks.*

1. Describe the various types and applications of bearing seals
2. Describe the various types and uses of pillow blocks

SECTION THREE POWER TRANSMISSION 44 HOURS

A. Couplings 8 Hours

Outcome: *Describe the types, application, replacement and maintenance of couplings.*

1. Describe types and characteristics of rigid couplings.
2. Describe types and characteristics of flexible couplings.
3. Describe types and characteristics of special purpose couplings.
4. Describe various coupling applications.
5. Describe coupling removal and installation procedures.
6. Describe coupling maintenance procedures.

B. Clutches and Brakes 8 Hours

Outcome: *Describe the types, applications, replacement and maintenance of clutches and brakes.*

1. Describe the types, principles of operation and applications of mechanical clutches.
2. Describe the types, principles of operation and applications of hydraulic clutches.
3. Describe the types, principles of operation and application of electric clutches.
4. Describe the types, principles of operation and applications of special purpose clutches.
5. Describe the methods of actuating clutches.
6. Describe clutch selection, installation and maintenance procedures.
7. Describe the types and principles of operation of brakes.

C. Shafting, Fits and Accessories 4 Hours

Outcome: *Describe shafts, soft materials and accessories.*

1. Describe the types and applications of keys and splines.
2. Describe the types and applications of locking devices used with shafting.
3. Describe the types, uses, selection and characteristics of shafting.
4. Describe the system of fits for shafting and hubs.

D. Power Transmission—Belts 6 Hours

Outcome: *Identify and describe installation and maintenance procedures for belt power transmissions systems.*

1. Describe the types, construction and applications of V-belts.
2. Describe V-belt installation and maintenance procedures.
3. Describe the type, function and applications of synchronous belts.
4. Describe synchronous belt installation and maintenance procedures.
5. Describe the types, construction, application and maintenance of sheaves and pulleys.
6. Describe the types, construction and application of flat belts.
7. Describe flat belt installation maintenance procedures.

E. Power Transmission—Chain 6 Hours

Outcome: *Identify and describe installation and maintenance procedures for chain power transmission systems.*

1. Describe the type, construction and application of power transmission chain.
2. Describe power transmission chain standards and selection criteria.
3. Describe the installation and maintenance procedures for power transmission chains.
4. Describe the types and applications of chain sprockets.
5. Describe chain sprocket mounting, removal and maintenance procedures.

F. Gearing Fundamentals 5 Hours

Outcome: *Explain the fundamental terminology and characteristics of gears.*

1. Explain gear terminology.
2. Describe the characteristics of various types of gears.
3. Describe the characteristics of various gear systems.

G. Gear Installation and Maintenance 5 Hours

Outcome: *Describe the installation, maintenance and overhaul procedures for gears and gearboxes.*

1. Describe methods of checking the mesh patterns on mating gears.
2. Describe methods of setting and checking the backlash on mating gears.
3. Describe gearbox installation.

H. Variable Speed Power Transmission Devices 2 Hours

Outcome: *Describe the installation and maintenance procedures for variable speed Power Transmission Devices*

1. Describe the construction, application and maintenance of belt type, variable speed units.
2. Describe the construction, application and maintenance of chain type, variable speed units.
3. Describe construction, application and maintenance of hydraulic type, variable speed units

SECTION FOUR ALIGNMENT.....8 HOURS**A. Cross Dial Alignment 8 Hours**

Outcome: *Align two machines using either the cross dial method or the reverse dial method.*

1. Explain the relationship between rim dial readings and misalignment.
2. Determine the alignment corrections required to align two machine shafts in the vertical plane, using the cross dial graphical method.
3. Determine the alignment corrections required to align two machine shafts in the horizontal plane using the cross dial graphical method.
4. Calculate the alignment corrections required to align two machine shafts in the vertical plane, using the cross dial formulae method.
5. Calculate the alignment corrections required to align two shafts in the horizontal plane, using the cross dial formula method.

SECTION FIVE RECIPROCATING COMPRESSORS.....24 HOURS**A. Compressor Fundamentals 4 Hours**

Outcome: *Describe the fundamentals of compressors.*

1. Explain gas theory and gas law.
2. Describe compressor applications.
3. Describe compressor classification methods.
4. Identify reciprocating compressor components.
5. Explain the basic compressor system.
6. Describe basic compressor terminology.

B. Repair of Compressor Stationary Components 4 Hours

Outcome: *Explain installation and repair of compressor stationary components.*

1. Describe frame/crankcase and foundation inspection and repair methods.
2. Describe the types, inspection and repair of compressor bearings.
3. Describe the inspection and repair procedures for cylinders.

C. Repair of Compressor Moving Components 4 Hours

Outcome: *Explain reciprocating compressor component inspection and repair.*

1. Describe the inspection and repair procedures for crankshafts.
2. Describe the types, inspection and repair of connecting rods.
3. Describe the installation, inspection and repair of crossheads.
4. Describe the function, inspection and reconditioning procedures of pistons and piston rods.

D. Repair of Compressor Valves and Gas Sealing..... 4 Hours

Outcome: *Describe reciprocating compressor valves and gas sealing inspection and repair.*

1. Describe the types, inspection and repair of compressor valves.
2. Describe the types, inspection and repair of piston rod packing.

E. Compressor Servicing 4 Hours

Outcome: *Explain reciprocating compressor servicing.*

1. Describe function and components of internal and frame lubrication systems.
2. Describe function and components of external frame lubrication systems.
3. Describe types of air filtration.
4. Describe types of compressor cooling systems.
5. Describe types of failure analysis techniques.

F. Compressor Overhaul and Start-up Procedures 4 Hours

Outcome: *Explain reciprocating compressor overhaul and start-up procedures.*

1. Explain the safety in regards to reciprocating compressors.
2. Explain the importance of manufacturer specifications and manuals.
3. Describe reciprocating compressor dismantling and reassembly procedures.
4. Describe compressor start-up procedures.

SECTION SIX.....CUTTING AND WELDING 8 HOURS

A. Oxyacetylene Equipment and Procedures 5 Hours

Outcome: *Describe the equipment and procedures used when performing heating, cutting and brazing operations.*

1. Describe personal safety devices and procedures applicable to gas welding, cutting and heating operations.
2. Describe the properties and storage of gases used for welding purposes.
3. Describe oxyacetylene components and common routine maintenance procedures.
4. Describe general set-up procedures of oxyacetylene equipment.
5. Describe oxyacetylene welding procedures.

6. Describe oxyacetylene cutting procedures.
7. Describe propane heating procedures and the use of temperature indicators.

B. Electric Arc Welding..... 3 Hours

Outcome: *Describe the procedures and equipment used in electric arc welding operations.*

1. Describe personal safety devices and procedures applicable to electric arc welding operations.
2. Describe types of electric arc welding machines.
3. Describe types and applications of electric arc welding electrodes.
4. Explain electric arc welding procedures.

SECTION SEVEN LUBRICATION 8 HOURS

A. Lubrication..... 8 Hours

Outcome: *Describe the use of lubricants in industry.*

1. Explain the characteristics of friction.
2. Describe the general characteristics of oil.
3. Explain lubrication theory.
4. Describe the types of oil and application of each type.
5. Describe the various oil lubrication systems and their applications.
6. Describe the properties and applications of the various types of greases.
7. Describe the various grease lubrication systems and their applications.
8. Describe the characteristics and application of dry solid lubricants.

SECTION EIGHT TRADE MATH 24 HOURS

A. Review of First Period Material

1. Demonstrate a knowledge of first period material including:
 - a) systems of measurement
 - b) manipulation of formulae and equations
 - c) ratio and proportion
 - d) percentages
 - e) surface speed - increase/decrease

B. Solving Related Trade Calculations

1. Calculate areas, volumes and capacities including:
 - a) rectangular
 - b) parallelogram
 - c) circular
 - d) triangular
 - e) cylindrical

C. Mechanics of Simple Machines

1. List and explain simple machine applications including:
 - a) levers
 - b) pulleys
 - c) screw jack
 - d) inclined plane
 - e) wheel and axle
 - f) gear trains

D. Atmospheric Pressure and Gas Laws

1. List atmospheric pressure and gas laws, explain their meanings and application principles including:
 - a) Barometer
 - b) Boyle's Law
 - c) Venturi principle
 - d) Pascal's Law

E. Coefficient of Expansion

1. List and explain the amount of thermal expansion or contraction that takes place with various materials including:
 - a) ferrous
 - b) non ferrous
 - c) synthetics

F. Alignment..... Hours

1. List and explain formula manipulation and calculations.

SECTION NINE.....APPLIED PRINT READING.....24 HOURS**A. Review of First Period Print Reading**

1. Demonstrate a knowledge of first period material.

B. Welding Specifications

1. Identify and explain welding specifications and symbols.
2. Identify and explain welding types including fillet and groove.
3. Explain and identify welding joints including:
 - a) butt
 - b) lap
 - c) corner
 - d) tee
 - e) edge

C. Practical Application of Print Theory

1. Demonstrate an ability to read, sketch and interpret prints pertaining to the trade including:
 - a) auxiliary views
 - b) partial views
 - c) assembly drawings
 - d) revolved and removed sections

- e) pipe threads
- f) structural steel shapes
- g) gears and gear trains
- h) rolling element bearings
- i) couplings and clutches
- j) castings
- k) single line drawings
- l) compressors
- m) gear boxes

2. Demonstrate an ability to interpret gear box and compressor drawings.

SECTION TEN SHOP WORK.....72 HOURS

- A. Gaskets**
- B. Bearings and Seal**
- C. Power Transmission**
- D. Alignment**
- E. Reciprocating Compressors**
- F. Cutting and Welding**
- G. Lubrication**

**THIRD PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE**

**UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE
FOLLOWING OUTCOMES AND OBJECTIVES.**

SECTION ONE..... HYDRAULIC AND PNEUMATICS 44 HOURS

A. Introduction To Hydraulics..... 9 Hours

Outcome: *Describe the fundamentals of power hydraulics.*

1. Describe hydraulic system functions.
2. Draw and explain a simple hydraulic circuit.
3. Draw and interpret basic hydraulic circuits.
4. Explain the principles of hydraulic pressure and force.
5. Explain the principles of flow.
6. Explain hydraulic energy, work, power and efficiency.

B. Hydraulic Valves 5 Hours

Outcome: *Describe the function and application of hydraulic valves.*

1. Explain the application, functions and operating principles of pressure control valves.
2. Explain the application, function and operating principles of directional control valves.
3. Explain the application, function and operating principles of flow control valves.
4. Explain the application, function and operating principles of stack valves and cartridge valves.
5. Explain the application, function and operating principles of proportional and servo valves.

C. Hydraulic Pumps and Actuators 6 Hours

Outcome: *Explain the application, function and operating principles of hydraulic pumps and actuators.*

1. List the types of hydraulic pumps and explain the operating principles, maintenance and applications of piston pumps.
2. Explain the operating principles, maintenance and applications of the various types of vane pumps.
3. Explain the application, function and operating principles of gear pumps.
4. Explain the applications, functions and operating principles of linear actuators.
5. Explain the application, function and operating principles of rotary actuators.

D. Accessories, Fluids and Seals 6 Hours**Outcome:** *Describe accessories, fluids and methods of sealing these fluids in hydraulic systems.*

1. Describe the characteristics, applications and installation procedures for various seals used in hydraulic components.
2. Describe the methods used to specify particulate fluid contamination.
3. Describe the types, purpose, application and methods of specifying filters used in hydraulic systems.
4. Describe the types, purpose and application of accumulators.
5. Describe the types, purpose and application of reservoirs.
6. Describe the types and properties of hydraulic fluids.

E. Troubleshooting and Maintenance 6 Hours**Outcome:** *Describe maintenance and troubleshooting of hydraulic systems.*

1. Describe open and closed loop circuits.
2. Describe maintenance and troubleshooting of conventional circuits
3. Describe basic troubleshooting of electro-hydraulic systems.

F. Pipe..... 4 Hours**Outcome:** *Describe fluid conductors and installation techniques.*

1. Describe pipefitting and installation techniques.
2. Describe tube, tube fittings and installation techniques.
3. Describe flexible hose, fittings and installation techniques.
4. Describe soldering.

G. Valves 2 Hours**Outcome:** *Describe the construction, operation, maintenance and repair of various kinds of fluid control valves.*

1. Describe valve types, construction, application and operation of valves.
2. Describe valve control methods and equipment.
3. Describe valve overhaul, maintenance and test procedures for valves.

H. Pneumatic Systems..... 6 Hours**Outcome:** *Explain pneumatic systems used in industrial applications.*

1. Describe the safety procedures necessary when working with pneumatics.

2. Describe the basic pneumatic system.
3. Describe pneumatic systems, pneumatic valves, and schematics.
4. Describe pneumatic actuators.
5. Describe pneumatic maintenance procedures.

SECTION TWO INDUSTRIAL REFRIGERATION AND HEAT EXCHANGERS 14 HOURS

A. Industrial Refrigeration 6 Hours

Outcome: *Describe the operation, basic maintenance and safety aspects related to industrial refrigeration systems.*

1. List and explain the basic principles that apply to the vapour compression cycle and apply these to the operation of the cycle.
2. List and briefly explain the various components, refrigerants, oils and accessories of a vapour compression cycle.
3. Briefly explain the control of refrigeration systems.
4. Describe flooded systems and some common service and equipment maintenance.
5. Describe liquids overfeed systems and some common service and equipment maintenance.
6. Describe centrifugal systems and some common service and equipment maintenance.
7. Describe gas plant systems and some common service and equipment maintenance.
8. Describe absorption systems and some common service and equipment maintenance.

B. Heat Exchangers 6 Hours

Outcome: *Describe the operation and maintenance of heat exchangers.*

1. Describe the principles of heat exchange.
2. Describe types and construction of heat exchangers.
3. Explain troubleshooting, maintenance and repairs of heat exchangers.

C. Insulation 2 Hours

Outcome: *Explain the use of insulation.*

1. List and describe types of insulating materials.
2. List the hazards of some insulating materials and explain hazard prevention methods.
3. Describe the insulating values of various insulating materials.
4. Describe insulation application techniques.
5. Explain the purpose of lagging (cladding).

SECTION THREE EXPLOSIVE AND AIR TOOLS 5 HOURS**A. Air Tools 2 Hours**

Outcome: *Explain the use and care of air tools in industry. Explain control components as used in industry.*

1. Describe safe operation of air tools.
2. Explain and describe the components and principles of air tools showing examples.
3. Describe the maintenance and storage of air tools.
4. Describe control components.

B. Explosive Actuated Tools 3 Hours

Outcome: *Identify and describe explosive actuated tools, power loads and fasteners.*

1. Differentiate between high and low velocity explosive actuated tools.
2. Describe explosive actuated tool power loads (low and high velocity), power load strength and safety requirements.
3. Describe explosive actuated tool fasteners, accessories and applications.
4. Assess base material suitability and related fastening requirements.
5. Describe explosive actuated system safety, firing procedure and tool maintenance.

SECTION FOUR COMPRESSORS AND FANS 26 HOURS**A. Screw Compressors and Lobe Blowers 8 Hours**

Outcome: *Describe the principles, components and maintenance of screw and lobe compressors.*

1. Describe types and operating principles of screw compressors.
2. Describe screw compressor components and accessories.
3. Describe maintenance, troubleshooting and overhaul of screw compressors.
4. Describe types and operating principles of lobe compressors.
5. Describe lobe compressor components and accessories.
6. Describe maintenance, troubleshooting and overhaul of lobe compressors.

B. Vane and Liquid Compressors 8 Hours

Outcome: *Describe principles, components and maintenance procedures for vane and liquid ring compressors.*

1. Describe types and operating principles of sliding vane compressors.
2. Describe sliding vane components and accessories.
3. Describe maintenance, troubleshooting and overhaul of sliding vane compressors.
4. Describe types and operating principles of liquid ring compressors.
5. Describe liquid ring compressor components and accessories.
6. Describe maintenance, troubleshooting and overhaul of liquid ring compressors.

C. Dynamic Compressors 7 Hours

Outcome: *Describe principles, components and maintenance of centrifugal flow compressors and axial flow compressors.*

1. Describe types and operating principles of centrifugal flow compressors.
2. Describe centrifugal flow compressor components and accessories.
3. Describe types and operating principles of axial flow compressors.
4. Describe axial flow compressor components and accessories.
5. Describe maintenance, troubleshooting and overhaul of axial flow compressors.

D. Fans 3 Hours

Outcome: *Describe principles, components and maintenance for fan, components and accessories.*

1. Describe types and operating principles of fans.
2. Describe fan components and accessories.
3. Describe maintenance, troubleshooting and overhaul of fans.

SECTION FIVE DRYERS 8 HOURS**A. Gas and Air Dryers 8 Hours**

Outcome: *Explain the use and care of air and gas dryers in industry.*

1. Explain safety of gas dryers.
2. Explain the principles of air and gas dryers.
3. Describe types of air and gas dryers.
4. Describe dryer maintenance and overhaul.

SECTION SIX ALIGNMENT AND SURVEY 14 HOURS**A. Laser Shaft Alignment 4 Hours**

Outcome: *Describe how to use laser equipment to align machine shafts and bores.*

1. Review safety, rim and face and cross dial shaft alignment.
2. Explain the basic principles of laser equipment used for shaft alignment.
3. Describe the use of laser systems to align bores.

B. Optical Levelling and Alignment 6 Hours

Outcome: *Describe optical levelling and alignment procedures.*

1. Describe optical levelling and alignment instruments.
2. Describe optical levelling procedures.
3. Describe optical alignment procedures.

4. Describe tight wire alignment procedures.

C. Machine Levelling 4 Hours

Outcome: *Describe how to install machinery at the correct location and elevation using laser equipment.*

1. Review safety, grouting and levelling.
2. Describe types of laser levelling equipment.
3. Describe laser levelling applications and procedures.

SECTION SEVEN COMPUTERS IN INDUSTRY 17 HOURS

A. Information Gathering, Computers and Catalogues 8 Hours

Outcome: *Use Internet, computers or catalogues to access equipment critical information.*

1. Describe accessing critical equipment information using Internet, computers and catalogues.

B. Managed Maintenance Systems..... 9 Hours

Outcome: *Describe computer maintenance management systems.*

1. Use software applications for industrial maintenance and inventory records.
2. Use software applications for vibration analysis and predictive maintenance.
3. Use software applications for industrial process control.

SECTION EIGHT.....NON-DESTRUCTIVE TESTING.....4 HOURS

A. Non-Destructive Testing 4 Hours

Outcome: *Explain non-destructive testing.*

1. Explain dye penetrant testing.
2. Explain magnetic particle testing.
3. Explain radiographic testing.
4. Explain ultrasonic testing.
5. Explain eddy current testing.

SECTION NINE ELECTRICAL 12 HOURS

A. Electrical Principles 6 Hours

The content of the Electrical section in this course outline, is not to suggest a Journeyman Millwright should complete tasks normally performed by Journeyman Electricians. The intent is to provide the Millwright with enough electrical knowledge so that safe decisions may be made when working on or around electrical equipment.

Outcome: *Describe the basic principles of electricity and electromagnetism.*

1. Describe the basic principles of electricity.
2. Explain the principles of magnetism and electromagnetism.
3. Describe the types of electric current, phases and cycles.
4. Explain the mathematical relationship between amps, volts, ohms and watts.

B. Practical Electricity 6 Hours

Outcome: *Describe practical applications of electrical principles, identify safety problems, solve basic electrical problems and interpret basic electrical circuits.*

1. Explain the safety procedures applicable when working on electrical equipment.
2. Identify potential electrical equipment hazards.
3. Describe the use of circuit breakers, disconnects, overload heaters and fuses.
4. Describe the principles and application of various electrical test meters.
5. Describe basic wiring systems.
6. Explain the purpose of electrical code.
7. Describe using test meters for testing circuits.
8. Describe electric motor replacement and maintenance procedures.

SECTION TEN TRADE MATH 16 HOURS

A. Hydraulic, Electrical and Advanced Mechanical Calculations

1. Demonstrate the ability to calculate and apply the following:
 - a) mechanical advantage ratios
 - b) pressure, force and area relationships
 - c) intensifier
 - d) piston, rod areas
 - e) pump torque requirements
 - f) relief valve settings
 - g) cylinder sizing
 - h) speed and capacities
2. Demonstrate the ability to calculate and apply the following:
 - a) Ohm's law
 - b) series and parallel circuits
3. Demonstrate the ability to perform advanced mechanical calculations including:
 - a) surface speed
 - b) RPM
 - c) ratios
 - d) feed

SECTION ELEVEN PRINT READING 16 HOURS**A. Reading, Interpretation and Cross Reference of Drawings of the Various Systems**

1. Demonstrate an ability to read and interpret information contained on the various prints the Millwright is involved with including:
 - a) assembly drawings
 - b) installation drawings
 - c) sectional drawings

B. Reading Isometric of Orthographic Multi-view Sketches of Complete Systems

1. Interpret isometric, orthographic multi-view sketches.

SECTION TWELVE.....SHOP WORK 64 HOURS**A. Hydraulics and Pneumatics****B. Industrial Refrigeration and Heat Exchangers****C. Explosive and Air Tools****D. Compressors and Fans****E. Dryers****F. Alignment and Survey****G. Computer in Industry****H. Non-Destructive Testing****I. Electrical**

**FOURTH PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE**

**UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE
FOLLOWING OUTCOMES AND OBJECTIVES.**

SECTION ONE..... PRIME MOVERS 49 HOURS

A. Stationary, Industrial. Engine Fundamentals..... 3 Hours

Outcome: Explain the working fundamentals of industrial stationary engines.

1. Identify the major components of stationary industrial engines.
2. Explain engine operating principles.
3. Describe engine classifications methods.

B. Engine Component Identification and Repair..... 10 Hours

Outcome: Inspect and repair the major components of stationary industrial engines.

1. Explain the appropriate safety procedures applicable to stationary industrial engines.
2. Describe disassembly and assembly procedures peculiar to stationary industrial engines.
3. Describe the function, construction, inspection and repair of engine blocks and cylinder liners.
4. Describe the function, construction, inspection and repair of the pistons and piston pins and piston rings.
5. Describe the function, construction, inspection and repair of connecting rods, crankshafts, flywheels and harmonic balancers.
6. Describe the function, construction, inspection and repair of camshafts, lifters and cam drives.
7. Describe the function, construction, inspection and replacement of engine bearings.
8. Describe the function, construction, inspection and repair of cylinder heads.

C. Engine Systems and Servicing 9 Hours

Outcome: Perform required servicing and preventive maintenance procedures on stationary industrial engines.

1. Describe the lubrication systems, function, operation, inspection and service.
2. Describe the crankcase ventilation systems, function, operation, inspection and service.
3. Describe the cooling systems, function operation, inspection and service.
4. Describe the induction systems, functions, operation, inspection and service.
5. Describe the ignition systems, function, operation, types, inspection and service.
6. Describe the fuels and fuel systems, function, types, operation, inspection and service.
7. Describe the starting systems, function, operation, types, inspection and service.
8. Outline methods used in basic tune-up, trouble-shooting and failure analysis.
9. State the purpose and methods of engine preventive maintenance programs.

10. List the functions of sensors used in industrial engines.

D. Engine Installation and Startup..... 2 Hours

Outcome: *Describe the procedures for installing and starting stationary industrial engines.*

1. State correct engine installation procedures.
2. Explain engine start-up procedures and checks.

E. Steam Turbines 12 Hours

Outcome: *Describe working principles, installation, start-up, maintenance and repair procedures for steam turbines.*

1. Explain the safety procedures applicable to steam turbines
2. Describe the types, applications, advantages and disadvantages of steam turbines.
3. Describe the working principles of steam turbines.
4. Describe the function, inspection and maintenance of small steam turbine components and systems.
5. Describe the function of large steam turbine components and systems.
6. Describe disassembly/reassembly, inspection, servicing and maintenance procedures for large steam turbines.
7. Describe installation and start-up procedures for steam turbines.
8. Describe equipment related to the operation of steam turbines.

F. Gas Turbines 6 Hours

Outcome: *Describe working principles, installation, start-up, maintenance and repair procedures for gas turbines.*

1. Describe the applications, advantages and disadvantages of gas turbines.
2. Describe the working principles of gas turbines.
3. Describe the functions of gas turbine systems and components
4. Describe inspection, servicing and maintenance procedures for gas turbines
5. Describe installation and start-up procedures for gas turbines

G. Governors 7 Hours

Outcome: *Describe the operating principles and maintenance procedures for the various types of governors used on industrial stationary engines and steam and gas turbines.*

1. Describe the application of governors with regards to industrial stationary engines, steam turbines and gas turbines.
2. Describe the operating principles of mechanical and mechanical-hydraulic governors.
3. Describe the operating principles of hydraulic governors.
4. Describe the operating principles of electro-hydraulic governors.
5. Describe the operating principles and adjusting procedures for overspeed trip mechanisms.
6. Describe diagnosis, maintenance and safety procedures for turbine and stationary engine governors.

SECTION TWO VIBRATION 20 HOURS

A. Vibration Analysis 8 Hours

Outcome: *Explain causes of vibration and ways to detect what causes a machine to vibrate.*

1. Explain vibration using the associated terminology.
2. Describe methods of measuring vibration.
3. Describe how strobe lights are used to measure phase angles and check shaft rpm.
4. Describe machine signature and its importance in vibration analysis.
5. Explain the causes of vibration in rotating equipment.
6. Explain basic vibration analysis.
7. Explain the use of vibration analysis as a part of a predictive maintenance program.
8. Describe solutions to vibration problems.

B. Balancing 4 Hours

Outcome: *Explain balancing methods.*

1. Describe causes of imbalance.
2. Describe the types of imbalance.
3. Define imbalance and balancing.
4. Explain imbalance correction methods and considerations.
5. Explain the single plane method of balancing.
6. Explain the two-plane vector method of balancing.

C. Electrical Controls and Troubleshooting 4 Hours

The content of the Electrical section in this course outline is not to suggest a Journeyman Millwright should complete tasks normally performed by Journeyman Electricians. The intent is to provide the Millwright with enough electrical knowledge so that safe decisions may be made when working on or around electrical equipment.

Outcome: *Explain industrial control principles.*

1. Explain the safety procedures applicable to industrial controls.
2. Describe troubleshooting techniques.

D. Industrial Controls: Schematics, Ladder Diagrams and Logic Control..... 4 Hours

Outcome: *Explain industrial control principles.*

1. Interpret electrical ladder diagrams and understand electrical troubleshooting techniques.
2. Interpret schematic diagrams for pneumatic control systems and explain troubleshooting techniques.
3. Describe air logic control operation.

SECTION THREE MACHINE LEVELLING 7 HOURS

A. Advance Alignment..... 7 Hours

Outcome: *Align and then purposely misalign a multiple chain of cold, non-rotating machines to a very high degree of accuracy with the expectation that the machines will shift, move and expand into an almost perfectly aligned state when running hot and loaded.*

1. Review safety, rim and face and cross dial shaft alignment.
2. Explain the various techniques used to measure machine thermal and process movement.
3. Demonstrate graphical solutions for solving multi-machine shaft alignment.

SECTION FOUR PUMPS.....16 HOURS

A. Dynamic Pump Selection..... 4 Hours

Outcome: *Explain the working principles and selection procedures for dynamic pumps.*

1. Explain dynamic pump principles.
2. Explain the procedure for selecting dynamic pumps.

B. Dynamic Pump Construction 6 Hours

Outcome: *Explain the construction of dynamic pumps.*

1. Describe pump impeller styles.
2. Describe types and applications of dynamic pumps.
3. Describe pump and system components.

C. Positive Displacement Pumps 4 Hours

Outcome: *Explain the construction, selection and operation of positive displacement pumps.*

1. Explain positive displacements pump principles.
2. Describe types and applications of reciprocating pumps.
3. Describe types and applications of rotary positive displacement pumps.
4. Describe pump and system components.

D. Pump Operation and Repair 2 Hours

Outcome: *Perform pump troubleshooting, maintenance and repair procedures.*

1. List conditions that affect pump operations.
2. Describe pump maintenance and repair procedures.

SECTION FIVE MECHANICAL SEALS AND PACKING.....8 HOURS

A. Mechanical Seals 5 Hours

Outcome: *Describe the principles, inspection and replacement procedures for mechanical seals.*

1. Describe the working principles and components of mechanical seals.
2. Describe the various types of mechanical seals.
3. Describe the procedures for inspecting and replacing mechanical seals.

B. Compression Packing..... 3 Hours

Outcome: *Describe the principles, and inspection and replacement procedures for compression packing.*

1. Describe the working principles and components of compression packing.
2. Describe the application of compression packing.
3. Describe the procedure for re-packing pumps and valves.

SECTION SIX..... CONVEYOR SYSTEMS.....16 HOURS

A. Belt Conveyors 6 Hours

Outcome: *Describe the application, operation and maintenance of belt conveying systems.*

1. Describe general conveyor belt designs.
2. Describe belting construction, joining and repair methods.
3. Describe conveyor belt pulleys and drives.
4. Describe conveyor belt carrying and return idlers.
5. Describe maintenance and setup procedures for conveyor belts.

B. Chain, Bucket, and Screw Conveyors 5 Hours

Outcome: *Describe the application, operation and maintenance of various conveyor systems.*

1. Describe chain conveyor applications, construction, maintenance and repair.
2. Describe bucket elevator applications, construction, maintenance and repair.
3. Describe screw conveyor applications, construction, maintenance and repair.
4. Describe pneumatic conveyor applications, construction, maintenance and repair.
5. Describe vibrating and air slide conveyor application, construction, maintenance and repair.

C. Package Handling Roller Conveyors 5 Hours

Outcome: *Describe the construction, maintenance and repair of package roller conveyors and their accessories.*

1. Describe characteristics and construction of package handling roller conveyors.
2. Describe repair and maintenance procedures for roller conveyors.

3. Describe the accessories used with package handling roller conveyors.
4. Describe repair and maintenance procedures for roller conveyor accessories.

SECTION SEVEN PLANNING AND SCHEDULING 4 HOURS

A. Maintenance Planning..... 4 Hours

Outcome: *Explain the planning of maintenance procedures for machine maximum uptime and safety.*

1. Describe estimating procedures.
2. Explain purchasing procedures.
3. Explain maintenance scheduling and record keeping.

SECTION EIGHT..... TRADE MATH 16 HOURS

A. Hydrostatic head as Applied to Centrifugal Pumps

1. Demonstrate and explain the usage of mathematics operation including:
 - a) psi to ft. of head
 - b) specific gravity
 - c) impeller diameters
 - d) gallons per minute
 - e) horsepower requirements
 - f) net. positive suction head
 - g) efficiencies
 - h) frictional losses
 - i) multi-stage pumps

B. Advanced Problem Solving

1. Demonstrate advanced problem solving including:
 - a) alignment
 - i) slope triangles
 - ii) graphs
 - iii) formulae
 - b) hydraulics
 - i) horsepower requirements
 - ii) gallons per minute
 - c) torque/air winches
 - i) ft. lbs.
 - ii) N.m
 - iii) winding radius
 - iv) brake capacity charts
 - d) mechanical advantages
 - i) compound machines
 - e) trig calculations
 - i) bolt circle layout
 - ii) offsets
 - iii) alignment
 - iv) sine laws
 - v) vectors

SECTION NINE PRINT READING 24 HOURS

A. Reading, Interpretation and Cross Reference of Industrial Drawings

1. Installation and repair of:
 - a) engines
 - b) pumps
 - c) conveyor systems
 - d) elec. pneumatic schematics

SECTION TEN WORKING AND COACHING SKILLS AND ADVISORY NETWORK 0 HOURS

A. Working and Coaching Skills and Advisory Network. 0 Hours

1. Describe the following coaching skills used for training apprentices:
 - a) identify the point of lesson
 - b) link the lesson
 - c) demonstrate a skill
 - d) provide opportunity to practice a skill
 - e) give feedback to learner
 - f) assess the learner's progress
2. Describe the role and purpose of the advisory network and the Provincial Apprenticeship Committee for the Millwright trade.

SECTION ELEVEN SHOP WORK 80 HOURS

- A. Prime Movers**
- B. Vibration**
- C. Machine Levelling**
- D. Pumps**
- E. Mechanical Seals and Packing**
- F. Conveyor Systems**
- G. Planning and Scheduling**

2. Objectives

- 1. To study the effect of temperature on the rate of reaction.
- 2. To determine the activation energy of the reaction.
- 3. To study the effect of concentration on the rate of reaction.
- 4. To study the effect of catalyst on the rate of reaction.

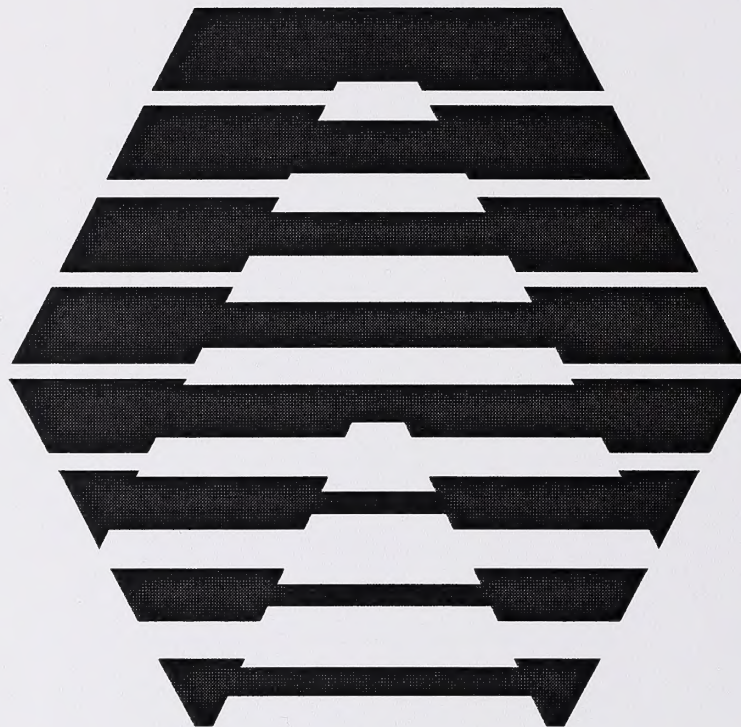
3. Materials and Apparatus

4. Procedure

The reaction between potassium persulfate and potassium iodide was studied. The reaction was carried out in a series of test tubes. The temperature of the reaction mixture was varied from 20°C to 40°C. The rate of reaction was determined by measuring the time taken for the reaction to complete. The activation energy of the reaction was determined by plotting the logarithm of the rate constant against the reciprocal of the absolute temperature. The effect of concentration on the rate of reaction was studied by varying the concentration of potassium persulfate and potassium iodide. The effect of catalyst on the rate of reaction was studied by adding a small amount of potassium iodide to the reaction mixture.

5. Results and Discussion

- 1. The rate of reaction increased with increasing temperature.
- 2. The activation energy of the reaction was found to be 50 kJ/mol.
- 3. The rate of reaction increased with increasing concentration of potassium persulfate and potassium iodide.
- 4. The rate of reaction increased with the addition of a small amount of potassium iodide as a catalyst.



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